OBSERVATIONS ON SOME DISEASES OF PLANTATION RUBBER IN MALAYA

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OBSERVATIONS ON SOME DISEASES OF PLANTATION RUBBER IN MALAYA.

By F. T. BROOKS, M.A.,

Senior Demonstrator of Botany, Cambridge University; sometime Government Mycologist, Federated Malay States.

(With Plates XXXIII—XXXV.)

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1. *Introduction.*

The present paper is an account of observations made upon some diseases of plantation rubber while the writer was acting as Government Mycologist in the Federated Malay States during 1914. Accounts of Pink Disease caused by *Corticium salmonicolor* and of the disease caused by *Ustulina zonata* have been published in separate papers (5, 7) and are only briefly mentioned here.

Generally speaking, Para rubber is a particularly healthy tree not only in its home in the valley of the Amazon but also in Ceylon, Malaya, Borneo, Java, and Sumatra, where such enormous areas have been

planted with it that the plantation industry is superseding the collection of rubber from wild sources. In Malaya large numbers of estates are contiguous to one another, and in travelling by rail from Penang to the borders of Johore one passes through an almost continuous rubber forest, broken here and there by other cultivations or by tin-mining areas and only once interrupted by a considerable jungle belt. These estates are usually devoid of inter-crops, hence this enormous tract of country, planted with a single product, would offer favourable opportunities for the establishment of disease on a serious scale were it not for the robust nature of *Hevea brasiliensis*, its relative immunity from disease, and the measures already taken to check fungoid parasites. Fortunately no disease of an epidemic nature has yet attacked plantation rubber with the possible exception of Pink Disease (7), which sometimes affects numbers of trees simultaneously in certain parts of the country during wet weather. It is probable, however, that Pink Disease can be kept under control if proper precautions are taken. No serious leaf disease of *Hevea* has yet been recorded in the East and the type of leaf, thin but tough, is one not specially liable to fungoid attack. One can safely say that plantation rubber is at present at least as healthy as most of the agricultural crops of temperate countries.

Although plantation rubber has been so healthy hitherto it must be emphasised that this happy state can only be maintained by continued vigilance in the treatment of disease as soon as it appears. The planting of enormous areas with one kind of plant offers special facilities for the propagation of disease unless any danger which threatens is dealt with drastically at once. It is fortunate for the plantation rubber industry that planters as a body are keen to combat disease and it is now the rule on estates to seek expert assistance as soon as troubles of this nature arise. Planters have by experience developed sound views on the subject of plant sanitation. The ravages of *Hemileia vastatrix* and other injurious organisms upon coffee in Ceylon has made a deep impression upon them. Many Malayan planters were formerly planters in Ceylon where they had actual experience of the effect of disease in the coffee industry or heard about it from the older men, and not a few saw similar ravages upon coffee in the Federated Malay States before the cultivation of this crop on a large scale was abandoned.

Within the last few years estate practices have changed in a direction that conduces to maximum vigour in the trees. Whereas it was formerly customary to plant 350 and more trees to the acre it is now usual to

plant only about 100 per acre. On many older estates thinning out has reduced the number of trees per acre to 80 or 90. Now that overcrowding is prevented the trees have a better chance of attaining their natural habit of growth, and air and light being freely admitted to all parts of the tree there is less danger of the establishment of disease. Where estates are thinned out it is necessary for the rubber stumps to be removed from well below the surface of the ground, otherwise there will be danger of root troubles later.

The methods of tapping in vogue at present are much more conservative than those formerly practised and longer periods are allowed for bark renewal, all of which tends to preserve the health and vigour of the trees. Many of the older trees were overtapped during the boom of 1910 and in consequence are poor specimens at the present day.

On account of the reduction in the number of trees per acre on most estates in comparison with the number formerly customary, each tree is now of more value as a potential or actual latex producer, for in the long run an acre bearing 100 trees will yield more rubber than an acre in which 350 trees remain. An estate containing 80 to 90 trees per acre cannot afford to lose many trees through disease, hence the smaller the number of trees per acre the more important does it become to do everything possible to ensure vigour in the trees and, if disease does appear, to treat it as soon as possible. The retention of only 40 trees per acre has been advocated by some authorities but the loss of a few of these trees from disease would cause such a serious reduction in the output of latex that upon this consideration alone it would appear preferable to retain about 80 trees to the acre.

When trees are killed by disease in plantations more than two or three years old it is usually not worth while to replant vacancies as supplies become crowded out by the older trees unless the vacant areas are extensive.

It is found advisable on most estates to keep a special coolie gang to deal regularly with pests and diseases, the size of the gang being regulated according to the amount of work to be done. Upon estates affected by Pink Disease the maintenance of a pest gang sufficiently large to go over the whole estate once in three or four weeks is an imperative necessity. European supervision should always be exercised over the treatment of disease although coolies often become remarkably expert in finding unhealthy trees.

As is only natural, managers of estates sometimes express regret at the cost of the pest gang though many of them realise that money

so spent is in the nature of insurance for the future. The welfare of the plantation rubber industry is dependent upon many factors, but it is obvious that without health in the trees this flourishing industry would cease to exist.

2. *Fomes lignosus*, Klotzsch.

This fungus which is the commonest cause of root disease of *Hevea* in Malaya is better known under the name, *Fomes semitostus*. Petch (11), however, has pointed out that *Fomes semitostus* proper is an entirely different fungus and that the correct designation of the fungus causing root disease of *Hevea* is *Fomes lignosus*, Klotzsch.

Soon after the establishment of rubber estates upon an extensive scale in Malaya this fungus became particularly troublesome in young plantations. As is well known it begins to grow upon the stumps which remain after the operations involved in planting up jungle land, and spreads thence by means of thick, yellowish white, mycelial strands which travel underground to the roots of young rubber trees. When the mycelium reaches the collar of the tree and spreads around it the tree dies.

Until recently the only mode of treatment for this disease used on a large scale lay in the destruction of affected trees and the isolation of diseased areas by means of trenches, but according to Richards (12) and Colenbrander (9) considerable success has been obtained by treating the roots of trees in the early stages of attack in the following manner. All trees are examined by opening the soil around the collar and if traces of mycelium are found the roots are fully exposed. Dead portions of roots are cut off, the external mycelium around living parts is scraped away, and the surfaces are then covered with a thin Bordeaux paste. The surrounding area is dug, all mycelial strands and dead wood being burnt. Richards (12) states that 75 per cent. of the trees affected on some estates have been successfully treated in this manner. A method similar to the above, but in which carbolineum is used instead of Bordeaux mixture, is described by Rutgers and Arens (16) as being used in Sumatra by Ris.

Since *Fomes lignosus* has been recognised to be a serious root parasite it has become customary on some estates to clear the land of jungle stumps and other timber a few years after planting. The cost of clearing varies greatly in different districts and depends largely upon the relative heaviness of the jungle that formerly covered the ground. Some of

the stumps of old forest trees are so large and so resistant to decay that it is very expensive to remove them. Where, however, stumping can be carried out at a low figure before the estate comes into bearing the operation insures against serious attacks of root disease and facilitates the movements of coolies engaged in weeding and tapping. If the cost of clearing the timber is high, and *Fomes* does not threaten seriously, the cheapest course will probably be to treat root disease as it appears.

Even on estates which are apparently equally encumbered with timber the prevalence of *Fomes* varies greatly. Some plantations are seriously troubled by it in the early years, others are never much affected. Soils which are either very loose or clayey seem to favour the disease, soils of an intermediate character being less liable to it. The underground strands of the fungus are sometimes found at a depth of two and a half feet in loose soils but usually they are not more than 18 inches below the surface.

As Petch (10) points out, trees that are invaded by white ants have generally been previously attacked by *Fomes lignosus*. When such trees have been blown over, examination often fails to reveal signs of the fungus which together with much of the diseased wood has been consumed by the termites.

Even though the stumps and underground timber are not removed after planting, most estates which are properly managed become practically free from *Fomes* as they become older. This is due to the preference shown by *Fomes lignosus* for living upon timber in the early stages of decay; as the wood becomes more and more rotten there s less likelihood of *Fomes* growing upon it. *Fomes lignosus* comparatively rarely attacks old rubber trees and the death of many old trees attributed to it is likely to have been really caused by *Ustulina zonata* as described by the writer (5) elsewhere, or by *Sphaerostilbe repens* as will be pointed out later in this paper.

With the general decrease of this disease the fructifications of the fungus are now more rarely seen. The growth of lalang grass in badly kept estates appears to favour the development of fructifications at the base of diseased rubber trees, and upon one low-lying estate seen by me the fruit bodies were produced in abundance along the sides of the drains.

A large number of fructifications were examined by the writer at different times of the year and the large majority of them were found to be sterile. Sections of fructifications which were apparently mature repeatedly failed to show functional basidia. I never succeeded in

obtaining a spore deposit, for even when sections showed that spore-producing basidia were present their number was very small. In view of the apparent paucity of spore production it would be interesting to have fuller information concerning the manner in which the fungus first begins to spread in a young rubber plantation.

3. *Polyporus rugulosus*, Lév.

On several occasions another polyporoid fungus was seen growing at the collar or upon exposed lateral roots of diseased rubber trees and it seemed likely that this fungus was the cause of the disease from which the trees suffered, although inoculation experiments are needed to settle this point definitely. The tissues of the host near the fructifications were invariably decayed, the foliage of the affected trees became thin, and the branches died back after the manner of trees attacked by a slowly growing root parasite. I saw this disease only in trees which were in tapping and it appeared to be more frequent in badly-drained low-lying estates than upon undulating land. One tree severely attacked by this fungus had been previously invaded by white ants.

The fructifications of this fungus are often densely imbricate and, in the aggregate, form large masses several inches across although a single pileus is only an inch or two in diameter. The upper surface is smooth, brownish, and zoned; the under pore-bearing surface is white when young, becoming yellowish brown with age; the pores are minute; the substance of the fructification is thin and although fleshy when young is leathery at maturity. Both in the colour of the pores and in the much thinner substance the fructifications of this fungus differ markedly from *Fomes lignosus*.

I am indebted to Miss Wakefield of the Royal Botanic Gardens, Kew, for kindly identifying this fungus as the *Polyporus rugulosus* of Léveillé. The type specimen of this fungus was obtained from tree trunks in Java and was described by Léveillé in 1844. Saccardo (17) has since placed the fungus in the genus *Fomes*, but on account of the texture of the fungus when young it is preferable to retain the original name. I have been unable to find any previous record of this fungus upon rubber trees.

Pending a further investigation of this fungus, rubber trees affected by it should be treated as for *Fomes lignosus*.

4. *Sphaerostilbe repens*, B. and Br.

During 1914 a considerable number of rubber trees were found to be affected by the fungus *Sphaerostilbe repens* which attacks the root system and advances upwards into the lower part of the trunk. The only previous record of this disease of rubber in Malaya was made by Richards (12) who mentions its occurrence in his report for 1912–13. According to the experience of the present writer this disease is by no means rare in older rubber planted on low-lying land in Malaya; it has been found in Northern Perak, in the district around Teluk Anson, and in the coast lands of Selangor. Only a few trees on undulating land were seen to be affected by it. The disease was first found on rubber estates in Ceylon in 1907 by Petch (10), who states that it is not confined there to the low country.

The foliage of rubber trees affected by *Sphaerostilbe repens* becomes thin and the branches gradually die back. The progress of the fungus being slow, a considerable time may elapse before the whole of the collar or all the lateral roots are affected and the tree succumbs.

If the roots of a tree affected by *Sphaerostilbe repens* are examined, the disease can be readily distinguished from the troubles caused by *Fomes lignosus* and by *Hymenochaete noxia* on account of the absence of external mycelium and by the presence of characteristic mycelial strands or rhizomorphs between the bark and the wood. These strands are usually flattened, are about $\frac{1}{8}$ inch in diameter, and vary in colour according to age from grey to dark brown or black; they are spread irregularly between the bark and the wood and sometimes occur also in the bark (cf. Plate XXXIII, fig. 1).

Even when the rhizomorphs have decayed, their former position is indicated by the presence of corresponding dark lines on the surface of the wood. I did not observe any tendency for these strands to spread independently through the soil. The affected trees were not usually contiguous to one another. The finer mycelium of this fungus permeates all parts of the bark and wood of the affected roots, the wood becoming discoloured and the bark often assuming a bluish purple colour when cut open. The roots of rubber trees affected by *Sphaerostilbe repens* often have a particularly foul smell, but this may be a secondary phenomenon induced by other agents of decay. The fungus advances up the tap root or along the laterals to the collar of the tree. On several occasions I observed it making considerable progress up the trunk, especially in the wood (cf. Plate XXXIV, fig. 3), and in these trees

boring beetles had begun to penetrate the diseased tissues. The shot-hole borer usually attacks portions of rubber trees which have been previously injured by some fungus; the region attacked by these insects is often not affected by a fungus advancing from the root system but in the specimens now referred to there was clearly a connection between the attack of the borers and the advance of *Sphaerostilbe repens* into the trunk. As the writer has pointed out elsewhere (5), rubber trees affected by the fungus *Ustulina zonata* advancing upwards from the collar are sometimes attacked by borers in the same manner.

Most of the trees seen to be affected by *Sphaerostilbe repens* were magnificent specimens of plantation rubber, 15 to 20 years old; the other trees had been recently brought into the tapping round or were ready for tapping.

The fructifications of *Sphaerostilbe repens* are of two kinds, both being minute. The first form to appear is the conidial stage which consists of white or pinkish white blobs about the size of a pin's head borne at the ends of pink stalks which are about $\frac{1}{16}$ to $\frac{1}{8}$ inch long and are hairy when young (cf. Plate XXXIII, fig. 2). This is the *Stilbum* stage and it arises from portions of the host permeated by the fungus or directly from the rhizomorphs; the conidial fructifications have also been seen on clayey soil lying in contact with diseased roots. These reproductive bodies have occasionally been found below the surface of the ground. The spores which arise at the extremities of the *Stilbum* type of fructification are hyaline, oval, and $10–20\mu \times 5–9\mu$ in size. Another *Stilbum* is an exceedingly common saprophyte on dead portions of rubber trees. This is *Stilbum cinnabarinum*, the conidial stage of *Megalonectria pseudotrichia*, readily distinguishable from the conidial stage of *Sphaerostilbe repens* by its red colour and smaller size. After the formation of conidia the fungus sometimes produces small, dark red perithecia, but I found these only rarely.

Sphaerostilbe repens sometimes lives entirely as a saprophyte on dead plant tissues and doubt has been expressed whether it is really parasitic on the roots of *Hevea*. In rubber trees affected by it that I was able to examine it was undoubtedly advancing into living tissues and therefore acting as a parasite. The actual means by which infection of the roots is effected by this fungus are unknown. The roots may sometimes have been already injured by adverse conditions such as bad drainage, and if the fungus entered such roots it might easily pass thence into healthy tissues.

Pure cultures of the fungus are easily established by sowing conidia upon sterilised blocks of *Hevea* wood or upon potato agar. A white mycelium rapidly develops which assumes first a pink and then a brownish tinge. After a time, sessile aggregations of spores of a yellowish pink colour arise on both media and these are often arranged in concentric zones. These spores are hyaline, oval, and very variable in size, the average limits being 16–20μ × 6–8μ though some are much smaller (cf. Plate XXXIV, fig. 4).

Spherical, thick-walled resting spores 9–10μ in diameter are formed in the hyphae and at the ends of short branches; these spores are brown in colour when mature. On blocks of *Hevea* wood, stalked conidial fructifications often arise similar to those which occur naturally. The mycelium penetrates the middle of these wood blocks, being specially abundant in the vessels and medullary rays. There was no sign of the formation of perithecia in these cultures.

Roots of seedling rubber plants in pots and of 4 year old trees on hilly land were inoculated with pure culture material of the fungus. In some cases the roots were wounded, in others the wood block bearing the mycelium, or the culture on agar, was placed against uninjured tissues. After an interval of nearly five months none of these plants (16 in all) showed signs of infection. This negative result points to the possibility that some, at present unknown, condition which disposes to susceptibility must exist before the fungus can invade the roots of a rubber tree. As pointed out above, bad aeration of the soil consequent on deficient drainage may be a factor in inducing the requisite condition for the fungus to enter.

Rubber trees affected by this fungus should be cut out and burnt. The attack is usually far advanced before the tree is seen to be diseased, hence it is generally not worth while to try to save the tree by excision of the affected parts. There is yet no evidence that the fungus spreads by subterranean strands but neighbouring trees should be examined, and to be on the safe side a trench should be dug around the affected tree at such a distance as to preclude the possibility of underground infection. If it is intended to replant the affected area after an interval, the soil should be deeply dug, all timber removed, and a liberal dressing of lime applied. This disease spreads more slowly than *Fomes lignosus*, and though it is not abundant in Malaya it is probable that the loss of some old rubber trees attributed to *Fomes* was really caused by *Sphaerostilbe repens*.

5. *Hymenochaete noxia,* Berk.

As pointed out by Brooks and Sharples (8) the Brown Root disease of plantation rubber is not of frequent occurrence in Malaya where it is commoner on trees about one-and-a-half or two years old than on mature trees. Petch (10) states that it is probably the commonest root disease of rubber in Ceylon although it causes less damage than *Fomes lignosus.* It is specially prevalent there in old cacao land. Many Malayan estates on the other hand have never been troubled with a case of *Hymenochaete.* As is well known, roots affected by this fungus are invested with masses of soil and small stones which become cemented to the bark. Patches of brown mycelium are frequently found intermixed with the débris on the exterior of the root, hence the popular name of the disease. The fungus does not produce mycelial strands which travel through the soil, so infection must result either through the roots coming into contact with other material containing the fungus or directly from spores. The fructifications of this fungus have not yet been found in Malaya, and Petch (10) states that its fruit-bodies have only occasionally been seen in Ceylon.

Trees affected by *Hymenochaete noxia* should be burnt, and in order to act on the safe side the area around them should be isolated by a trench. If the ground is to be replanted it should be dug over, freed from timber, and well limed.

Although it is customary to refer the brown mycelium associated with this disease in Malaya to *Hymenochaete noxia,* Berk., I have not seen the fructifications of this fungus and therefore cannot confirm its identification.

6. *Ustulina zonata* (Lév.), Sacc.

It has been thought desirable to include in this paper a summary of my investigations upon the root disease of plantation rubber caused by *Ustulina zonata,* a full account of which has appeared elsewhere (5).

This disease had not previously been recorded on rubber in Malaya, but Petch (11) had recently noted its occurrence in Ceylon estates especially where *Hevea* had been planted amongst tea which had been subsequently allowed to die out. In Ceylon this fungus causes a serious root disease of tea.

In Malaya this disease by no means infrequently attacks old rubber trees, although it is only in the few estates where groups of trees have been killed that serious damage has yet been done by this fungus.

The part of the tree chiefly affected is the collar which is usually attacked first on one side only, the bark collapsing. Neighbouring lateral roots and the tap root often become affected in the same manner and in advanced cases the disease may spread up the trunk to a height of three or four feet. If the diseased tissues are exposed, conspicuous black lines are often seen near the limits of the affected parts although these lines are not invariably present. The absence of external mycelium and of rhizomorphic strands between the bark and the wood distinguishes this disease from other well-known root troubles of *Hevea*. As the fungus progresses in the collar and root system of the tree the foliage becomes thin, the branches die back, and the whole tree succumbs unless successfully treated.

The fructifications of the fungus appear as closely adpressed plates, grey brown to blackish in colour, on the collar and exposed lateral roots of affected trees. The fructifications are easily overlooked, especially in wet weather when they become splashed with mud. The conidial stage present in young specimens of the fungus in Ceylon has not yet been found in Malayan specimens although adult fruit bodies are undoubtedly identical. The mature plate-like fructifications which may be several inches across are marked by an irregular and obscurely zoned surface punctured by minute dots. If the grey brown surface of a fruit body is scratched, a black layer is seen which may also become exposed by the natural wearing away of the thin covering. Below this black layer the perithecia are formed from which the spores subsequently exude in black masses.

Wood and bark invaded by the fungus become discoloured. The black lines often found near the margin of the affected tissues are caused by the aggregation and darkening of the hyphae which form a kind of sclerotic plate in the cells of these regions. Pure cultures of the fungus were established on blocks of *Hevea* wood in which similar black lines were formed. It is only when black lines in the tissues are associated with an extensive affection of the collar and root system of the tree that *Ustulina zonata* should be suspected, as two other fungi, *Nummularia pithodes* (B. and Br.), Petch, and a species of *Xylaria* both belonging with *Ustulina zonata* to the Xylariaceae and both common saprophytes on dead rubber wood, produce similar black zones. Inoculations of the roots of seedling *Hevea* plants and of 4 year old trees, just below soil level, with material of the fungus growing in pure culture were followed by the establishment of the fungus in the tissues, some of the seedlings being killed in consequence.

In Malaya it is likely that the fungus often begins to grow on decayed stumps from which it passes to the rubber trees, the fungus spreading from one tree to another by contact of diseased roots with healthy ones. On some of the older estates in which the disease has been found, however, very few stumps remain and it is likely that there are other means of infection. Some of the old trees affected by *Ustulina zonata* had been previously attacked by white ants. White ants frequently invade rubber trees attacked by *Fomes lignosus* and the reverse process may possibly occur in the case of *Ustulina zonata*.

It is important that this disease should be dealt with at an early stage although it is then rather liable to be overlooked. If the condition of the bark on one side of the collar of the tree arouses suspicion it should be examined, and if found to be diseased all discoloured tissues should be cut out and burnt and the exposed surfaces tarred; diseased lateral roots should be destroyed unless they are large, when the unhealthy tissues should be excised. If the fungus has penetrated so far into the tree that it would fall if all the affected tissues were cut out, the tree is doomed, but as the fungus spreads only slowly the tree may be kept in tapping until it ceases to yield latex in paying quantities. In order to act on the safe side, infected areas should be isolated by means of trenches.

7. *Botryodiplodia theobromae*, Pat.

After *Corticium salmonicolor*, this fungus causes the greatest amount of injury to the shoot system of *Hevea* in Malaya. *Botryodiplodia theobromae* may enter the tree in several ways; it may invade young shoots killed by *Gleosporium albo-rubrum* or by *Phyllosticta ramicola*, it may enter branches already attacked by Pink Disease caused by *Corticium salmonicolor*, or it may act as a wound parasite without association with attack by any other fungus. Whatever the mode of entry, *Botryodiplodia theobromae* spreads rapidly downwards in the tissues killing the branches and main stem as it proceeds so that the disease is popularly called "die-back." The fungus usually advances faster in the wood than in the bark, though in some trees attacked during 1914 the reverse was apparently the case.

Petch (10), Richards (12), and Bancroft (1) all point out that *Botryodiplodia theobromae* often attacks groups of rubber trees simultaneously and the same tendency has been noted by the writer. Rubber stumps have been affected by the fungus soon after being planted out though it was not possible to determine the manner of infection.

The only mode of treatment is to cut out and burn all affected parts as soon as the disease is seen. Prompt action is particularly necessary in dealing with this disease on account of the rapidity with which it develops. If an estate is being thinned out, the rubber trees which are discarded should not be allowed to remain lying in the plantation indefinitely as such material offers a good breeding-ground for this fungus.

Many different names have been given to this fungus but *Botryodiplodia theobromae* has the right of priority as far as its common conidial stage is concerned. In 1911 Bancroft (1) described the development of an ascus stage in its life-history. During my residence in Malaya I devoted special attention to trying to find the perithecia described by Bancroft but without success. Branches of *Hevea* attacked by *Botryodiplodia* were kept under conditions favourable for the formation of perithecia but in no case did ascus formation result. As far as I am aware no other observer has found the *Thyridaria* which Bancroft considers is the complete stage of the *Botryodiplodia*, and until confirmation of the presence of a perithecial stage is obtained it seems preferable to retain the name *Botryodiplodia theobromae* for the fungus.

8. *Bark Diseases.*

Diseased bark was frequently seen in rubber trees, but apart from a careful search in vain for the bark canker of Ceylon attributed by Petch (10) to *Phytophthora Faberi* I had no time to investigate troubles of this nature in detail. As soon as the bark of a rubber tree becomes diseased, boring beetles are almost certain to attack the affected tissues. Where boring beetles attack a tree high up there is obviously no connection between their invasion and the action of a root parasite as described above under *Ustulina zonata* and *Sphaerostilbe repens*. I have occasionally seen borers penetrating the laticiferous layer of healthy bark by continued attacks, but usually they can only successfully invade bark which is diseased.

None of the diseased bark examined in Malaya presented the features associated by Petch (10) with the bark disease caused by *Phytophthora Faberi* in Ceylon. Many attempts were made by culture experiments to isolate a *Phytophthora* from bark taken from the junction of healthy and diseased tissues but in place of it some species of *Fusarium* or other hyphomycete was invariably obtained. This, however, is not sufficient evidence to justify the belief that species of *Fusarium* are capable of

causing disease of *Hevea* bark. No mycologist who has resided in Malaya for any considerable period has yet isolated a *Phytophthora* from diseased rubber bark, hence the statement of Rutgers (15) of Java who after a brief visit to the Federated Malay States, and without isolating the supposed causative fungus, announced the presence there of a bark canker caused by *Phytophthora Faberi* cannot be considered conclusive. Until the fungus has been isolated from diseased bark and has successfully infected trees which have been inoculated it seems premature to say that the bark canker caused by *Phytophthora Faberi* occurs in Malaya.

Rutgers and Arens (16) consider that the burrs on rubber trees are often due to *Phytophthora Faberi*, a view for which the writer does not think sufficient evidence has yet been brought forward.

9. *Burrs.*

There are two kinds of burrs on rubber trees, one consisting of small, pea-like swellings in the bark, the other being irregular woody growths extremely variable in size which arise both on tapped and untapped surfaces though chiefly on the former. The pea-like nodules can be cut out with a knife as they are somewhat easily separated from the surrounding tissues. This kind of burr is of little economic importance. The irregularly shaped burrs on the other hand are of considerable economic importance as they seriously incommode tapping operations and may even render the renewed bark incapable of being tapped effectively. These burrs are specially abundant on trees that were overtapped during the boom of 1910.

Apart from Rutgers and Arens (16), mycologists are in agreement that burrs on rubber trees are not due to the action of parasitic organisms but are caused by some physiological disturbance.

Bateson (3) attributes the formation of the "pea" type of burr, which often occurs on the sites of old leaf scars, to the stimulus set up by the coagulation of latex in the tubes which formerly passed out to the leaves with the vascular bundles. Richards and Sutcliffe (13) put forward the view that the large, irregular burrs are likewise caused by the stimulus on the surrounding tissues set up by the coagulation of latex in tubes which belong to the laticiferous system of the stem. There is good evidence for both these views. A small percentage of burrs is doubtless due to wounds made in the wood through bad tapping.

With the conservative and more careful methods of tapping in

general use at the present time, burrs will probably be less troublesome in the future than in the past. The larger type of burr is difficult to treat but good results appear to have been obtained on some estates by using a plane to make the surface smooth after removing these irregular excrescences.

10. *Thread Blight.*

A white thread blight is of common occurrence on rubber trees in Malaya but it causes little harm. The mycelial strands of this fungus vary considerably in size and run long distances over the branches, matting the finer twigs and leaves together and sometimes enveloping the leaves with a fine felt of hyphae causing them to die. The fungus is conspicuous and should be cut out before it has had time to do any considerable harm. This white thread blight is very variable in character and it is possible that more than one species of fungus is involved. Thread blights rarely fructify and there is at present only one record of a fruiting stage in Malaya observed by Richards (12) who sent the fungus to England for identification. It was named *Cyphella Heveae* by Massee and is thus a member of the Thelephoraceae. Thread blight is of common occurrence on other cultivated trees in Malaya.

11. *Phyllosticta ramicola,* Petch.

This fungus affects young green twigs of *Hevea brasiliensis* and sometimes affords opportunity for the entrance of *Botryodiplodia theobromae* as pointed out by Richards (12) and Bancroft (1). It occurs more frequently on trees one to two years of age than on older ones and is usually most abundant towards the end of the year when the rains are heaviest. The fungus generally enters the twig at one or more of the leaf axils 6 to 18 inches below the apex, the fungus probably beginning the attack in the leaf axils because moisture is retained here better than elsewhere. The first sign of its development is the appearance of small brown patches which spread upwards and downwards causing first a blackish and then a brownish discoloration of the stem. At the same time enormous numbers of pycnidia scarcely visible to the naked eye are formed on the discoloured parts. The disease spreads rapidly downwards and as much as 3 feet of the stem may be killed in the course of a week. The extremities of the affected twigs, which are often not invaded by the fungus, die in consequence of the

failure of the water supply caused by the presence of the fungus below. On one low-lying part of an estate an outbreak of this disease was almost epidemic in character, more than 200 trees, one to two years old, growing on peaty soil being affected together. Trees of the same age on higher land with better soil remained unaffected. Poor drainage and a peaty soil often check the growth of rubber trees which appear generally to be more subject to disease under these conditions, possibly on account of a lessened resistance to parasitic organisms.

Branches affected by this fungus should be cut out and all diseased portions burnt. If an attack on young trees is observed in an early stage the trees which are still healthy should be sprayed at intervals with Bordeaux mixture.

A *Phyllosticta* was also sometimes found on the margins of rubber-leaves and inoculations showed that it could act as a weak parasite causing a brown discoloration of the leaves from the margin inwards. The spores of this *Phyllosticta* appeared to be identical with those of *Phyllosticta ramicola* but it was not possible to carry out comparative cultures to test this.

12. *Gleosporium albo-rubrum*, Petch.

Petch (10) first described this fungus as causing a die-back of the green shoots of *Hevea* in Ceylon which was often the forerunner of attack of the woody parts by *Botryodiplodia theobromae*. The fungus plays the same rôle in Malaya and what is apparently the same fungus often affects young leaves also. Both upon the young stem and upon the leaves the pustules of this fungus are pink in colour, the individual spores being hyaline and $14\text{–}20\mu \times 4\mu$ in size. On young stems of *Hevea* I have sometimes seen this fungus intimately mixed with *Phyllosticta ramicola*. Where *Gleosporium albo-rubrum* occurs on recently unfolded rubber leaves it causes them to shrivel from the margin and fall rapidly from the tree. On a few mature trees growing in low-lying land I have seen this fungus so abundant at the time of unfolding of the leaves after "wintering" that the ground below was thickly carpeted with the leaves which had been shed. Leaves of *Hevea brasiliensis* at the time of unfolding are of delicate texture and are much less resistant to fungoid attack than when fully developed. This was the only indication I saw of any present danger of a serious leaf parasite of plantation rubber.

13. *Cephaleuros* sp.

Although this alga is of no economic importance on rubber as is *Cephaleuros* on tea it is interesting to note that an organism of this nature can penetrate the leaves of *Hevea*, on which it is often found in the form of small brown spots more especially on the under-surface. Filaments of the alga grow out from these spots and terminate in groups of sporangia as shown in Plate XXXV, fig. 5. This alga is of common occurrence on the leaves of other plants in Malaya and is specially abundant on clove in which Ridley (14) states that it causes a serious disease.

14. *Loranthus* spp.

As pointed out by the writer (6) in a Malayan publication, two kinds of *Loranthus* occurred as semi-parasites on the branches of old rubber trees in a few estates in Negri Sembilan and in one or two areas some damage was being done by them. Bateson (4) has also recorded the presence of a species of *Loranthus* on rubber in Pahang. In the Negri Sembilan estates, portions of branches beyond the place of attachment of the parasites were often killed. The trees most severely affected were generally in poor condition, being badly burred and having been overtapped some years before. The foliage was thin and this circumstance probably assisted the parasites to become established, for in trees possessing a vigorous leaf canopy the shade cast by the crown tends to prevent the establishment of these troublesome plants. The development of *Loranthus* on a rubber tree is a drain upon its resources, and if such "mistletoes" are allowed to develop with impunity the tree will become impoverished, just as apple trees in some parts of England are weakened by the unchecked development of *Viscum album*.

All branches of rubber trees affected by these growths should be cut back well beyond the region to which the parasite extends.

Various species of *Loranthus* are of common occurrence in Malaya on many kinds of trees and shrubs. One of the species found on rubber trees grows frequently on *Melastoma malabathricum*, which is one of the commonest wayside shrubs in Malaya. The species of *Loranthus* seen on rubber trees are provided with runner-like processes which creep along the branches of the host giving off suckers here and there which form the means of attachment and the channels by which food substances are obtained. Some of the suckers become much swollen

and the stem of the host in the immediate vicinity is abnormally developed, the whole producing a large knob of hypertrophied tissue. Other suckers which are much closer together than the former kind are not associated with any marked hypertrophy of the host.

The leaves of these species of *Loranthus* are extremely variable in size and shape. Plate XXXV, figs. 6 and 7 are photographs of one of the kinds of *Loranthus* which affects rubber trees showing the creeping stems and the hypertrophied tissue where the parasite penetrates the host deeply.

In conclusion I wish to express my hearty thanks to Mr F. de la Mare Norris of the Agricultural Department, Federated Malay States, for permission to reproduce his drawings of *Sphaerostilbe repens* in Plate XXXIII, figs. 1 and 2, and for making the drawings for Plate XXXIV, fig. 4 and Plate XXXV, fig. 5. I am also indebted to Mr A. Sharples of the same department for taking for me the photographs used in Plate XXXV, figs. 6 and 7.

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EXPLANATION OF PLATES.

PLATE XXXIII.

Fig. 1. Root of rubber tree with strands and conidial fructifications of *Sphaerostilbe repens*. Natural size. (Water-colour sketch by Mr F. de la Mare Norris.)

Fig. 2. *Stilbum* stage of *Sphaerostilbe repens*. ×30. (Water-colour sketch by Mr F. de la Mare Norris.)

PLATE XXXIV.

Fig. 3. Photograph of rubber tree attacked by *Sphaerostilbe repens* and by boring beetles. The bark has been removed to show the upward extension of diseased wood (*d*) from the root system.

Fig. 4. Conidia of *Sphaerostilbe repens* formed in a pure culture on *Hevea* wood. Some spores are thick-walled. ×450.

PLATE XXXV.

Fig. 5. *Cephaleuros* sp. Material growing on a clove leaf. The species on rubber leaves is apparently the same. ×600.

Figs. 6 and 7. Photographs of branches of rubber trees attacked by *Loranthus*. + is a branch of *Hevea*, *p* is a part of the parasite, *h* in Fig. 7 is a mass of hypertrophied tissue belonging chiefly to the host.

× 1.

Fig. 1

× 30 diam.

Fig. 2

Sphaerostilbe repens, B. and Br.

Diseases of Plantation Rubber

Fig. 3

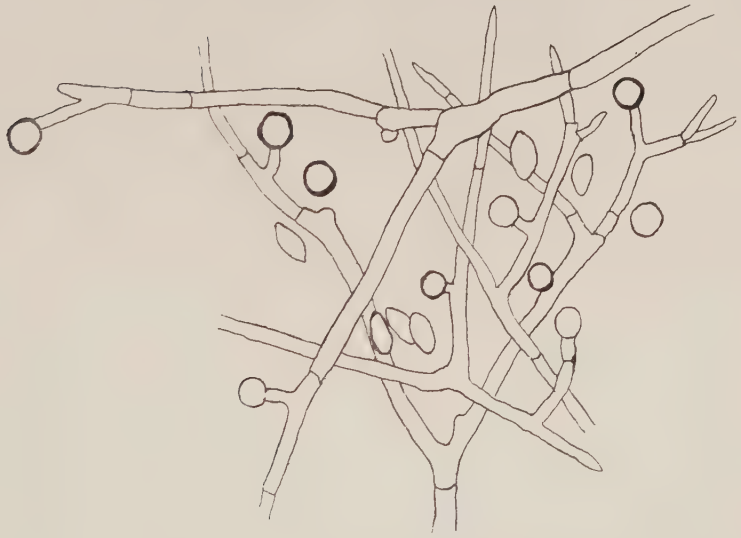

Fig. 4

Diseases of Plantation Rubber

Fig. 5

Fig. 6

Fig. 7

Diseases of Plantation Rubber